

CHAPTER 1

INTRODUCTION

1.1 Project Background

Flow pattern around a cylinder in cross flow and its heat transfer mechanism has fascinated among engineers, scientist and researchers for one or two decades. There are many practical cases exist involving flow around a cylinder in cross flow which has an extensive significant in engineering such as skyscrapers, cooling towers, offshore platform support, pipes, heat exchangers many more. Although there are large number of researches and studies discussed about flow around cylinder in cross flow existed in the past, this study focused on numerical simulation of the flow and heat transfer as well by using Lattice Boltzmann Method (LBM) algorithm.

1.1.1 Lattice Gas Automata

Lattice Boltzmann models were first based on Lattice Gas Automata (LGA) in that they used the same lattice and applied the same collision. Instead of particles, Lattice Boltzmann (LBM) deal with continuous distribution functions which interact locally (only distributions at a single node are involved) and which propagate after collision to the next neighbor node. This is the main advantage of LBM compare to LGA. The next step in the development was the simplification of the collision and the choice of different distribution functions. This gives LBM is more flexible than LGA.

1.1.2 Molecular Dynamics

In molecular dynamics (MD), one tries to simulate macroscopic behavior of real fluids by setting up the model which described the microscopic interaction as good as possible. This leads to realistic equation of states whereas LGA or LBM posses only isothermal relations between mass density and pressure. The complexity of the interactions in MD restricts the number of particles and the time of integration. A method somewhat in between MD and LGA is maximally discretized molecular dynamics.

1.1.3 Lattice Boltzmann Method

The lattice Boltzmann method (LBM) has developed into an alternative and promising numerical scheme for simulating fluid flows and modeling physics in fluids. Historically, the lattice Boltzmann approach developed from improvement of lattice gases, although it can also be derived directly from the simplified Bhatnagar-Gross-Krook (BGK) equation. The lattice Boltzmann method is based on microscopic models and macroscopic kinetic equations. The kinetic nature of the LBM introduces important features that distinguish it from other numerical methods. First, the streaming process of the LBM in velocity space is linear. Second, the incompressible Navier-Stokes (NS) equations can be obtained in the nearly incompressible limit of the LBM. The LBM originated from lattice gas approach (LGA), a discrete particle kinetics utilizing a discrete lattice and discrete time. The primary goal of LBM is to build a bridge between the microscopic and macroscopic dynamics rather than to deal with macroscopic dynamics directly. In other words, the goal is to derive macroscopic equations from microscopic dynamics by means of statistics rather than to solve macroscopic equation in Figure 1.1 below.

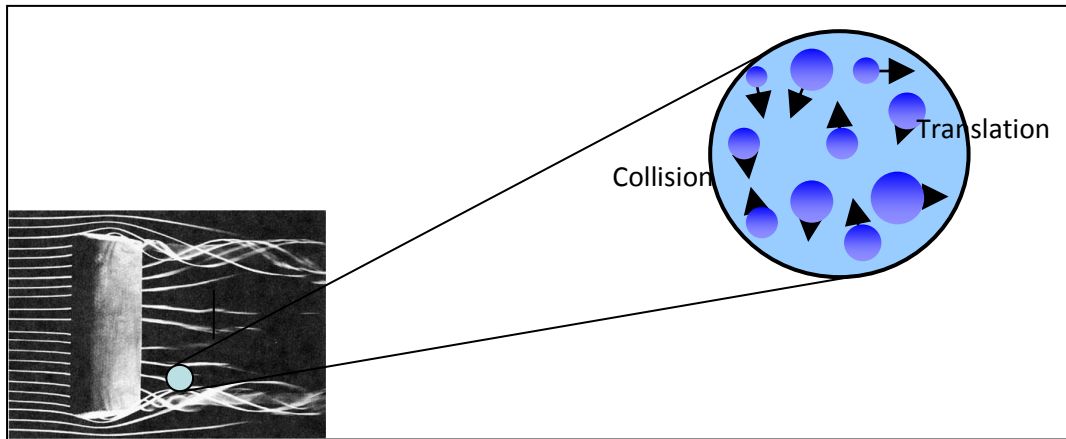


Figure 1.1: The relationship between macroscopic and microscopic.

Source: Azwadi 2007

1.2 Problem Statement

Understanding flow pattern and heat transfer mechanism from a heated cylinder in cross flow using Lattice Boltzmann Method.

1.3 Objective

- (i) To study flow pattern and heat transfer mechanism from a heated cylinder in cross flow.
- (ii) To study the flow pattern in a channel through a cylinder in cross flow
- (iii) To study the heat transfer mechanism of heated cylinder

1.4 Scope of Work

Low Rayleigh Number between 10^2 and 10^4 is used to study thermal flow in pressure driven parallel plate channel. In this case, Reynolds Number is fixed to 10^3 . For isothermal flow the value of Reynolds Number is chosen between 10^2 and 10^4 . Multi speed LBM D2Q9 microscopic velocity model is used to simulate the flow as it